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# PATENT APPLICATION

## Disk Control System and Control Method of Disk Control System

Inventors: **Yasuaki NAKAMURA**  
Citizenship: Japan

**Akinobu SHIMADA**  
Citizenship: Japan

**Hideo TABUCHI**  
Citizenship: Japan

Assignee: Hitachi, Ltd.  
6, Kanda Surugadai 4-chome  
Chiyoda-ku, Tokyo, Japan  
Incorporation: Japan

Entity: Large

TOWNSEND AND TOWNSEND and CREW LLP  
Two Embarcadero Center, 8th Floor  
San Francisco, California 94111-3834  
(415) 576-0200

# **DISK CONTROL SYSTEM AND CONTROL METHOD OF DISK CONTROL SYSTEM**

## **Cross-Reference to Related Applications**

5       The present application claims priority upon Japanese Patent Application No. 2003-027208 filed on February 4, 2003, which is herein incorporated by reference.

## **BACKGROUND OF THE INVENTION**

### 10    **1. Field of the Invention**

      The present invention relates to disk control systems and control methods of disk control systems.

### **2. Related Art**

15       As a method for supplying a storage region from a disk array device to a computer using the same, there is the method of setting logical devices (referred to in the following as "LDEVs"), which are logical storage regions that have been set in the storage region provided by the disk drives, and assigning  
20   these logical devices to logical units (referred to in the following as "LUs"), which are identifiers of the storage region that are given by the computer.

      This assignment of logical devices to logical units is currently performed by a manual operation in which the operator  
25   operates a management terminal of the disk array device in accordance with such circumstances as the needs of the computer's user or the operation mode of the disk array device (see for example JP 2001-337850A).

      However, with the recent advancements in the IT industry,  
30   the number of disk drives with which disk array devices are

equipped has increased sharply, so that there is the problem that the operator is forced to set an enormous number of LUs and LDEVs in the operation of disk array devices, and this poses a considerable managerial burden. Moreover, with storage  
5 virtualization, there is a need for technology for assigning storage regions economically in accordance with the actual state of utilization.

#### **SUMMARY OF THE INVENTION**

10 In view of the above-described circumstances, it is a main object of the present invention to provide an improved disk control system and control method for a disk control system.

To achieve this object, in one aspect of the present invention, a disk control system that receives a process command  
15 for writing or reading of data from an information processing device, and performs a write or read process of data with respect to a logical device corresponding to a logical unit specified by that process command, includes:

means for managing, as units, logical devices, which are  
20 logical storage regions that have been set in a storage region provided by a disk drive;

means for storing a correspondence between the logical devices and logical units, which are storage regions that have been set logically; and

25 means for assigning, when a process command has been received for a logical unit to which no logical device has been assigned, a logical device to that logical unit and performing processing with regard to that logical device.

Features and objects of the present invention other than  
30 the above will become clear by reading the description of the

present specification with reference to the accompanying drawings.

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

5        For a more complete understanding of the present invention and the advantages thereof, reference is now made to the following description taken in conjunction with the accompanying drawings wherein:

10        Fig. 1 is a diagram showing the configuration of a storage system in accordance with a working example of the present invention;

      Fig. 2 is a diagram showing the relationship between the ports, the LUs assigned to the ports, and the LDEVs assigned to the LUs, in a working example of the present invention;

15        Fig. 3 is a diagram showing the overall configuration of a disk array device, in accordance with a working example of the present invention;

      Fig. 4 is a diagram showing an example of an LU mapping table, in accordance with a working example of the present invention;

20        Fig. 5 is a diagram showing an example of a global LU mapping table, in accordance with a working example of the present invention;

25        Fig. 6 is a diagram showing an example of a global LDEV table, in accordance with a working example of the present invention;

      Fig. 7 is a diagram illustrating the principle of a type I process command, in accordance with a working example of the present invention;

30        Fig. 8 is a flowchart illustrating the processing of the

disk array device in the case that the type II process command is "Write" (data write command) , in accordance with a working example of the present invention;

Fig. 9 is a diagram illustrating the principle of a type II process command, in accordance with a working example of the present invention;

Fig. 10 is a diagram illustrating an example of an assignment method, in accordance with a working example of the present invention, for the case that the storage capacity set for the LUs is larger than the storage capacity of the LDEVs; and

Fig. 11 is a flowchart illustrating the processing of the disk array device in the case that the type II process command is "Read" (data read command) , in accordance with a working example of the present invention.

#### **DESCRIPTION OF THE PREFERRED EMBODIMENTS**

At least the following matters will be made clear by the explanation in the present specification and the description of the accompanying drawings.

##### *Overview of the Disclosure*

At least the following matters will be made clear from the following disclosure:

The logical devices correspond to the above-mentioned LDEVs, for example. The logical units correspond to the above-mentioned LUs, for example. The process commands may be commands as specified by the SCSI (small computer system interface) standard. The disk control system may be, for example, a disk array device as explained below.

With the disk control system of the present invention, when a process request has been received for a logical unit to which no logical device has been assigned, then a logical device is automatically assigned to that logical unit, so that  
5 there is no need for an operator or the like to manually assign an LDEV to that LU, and the operator is freed from such assignment tasks. Moreover, by adopting a configuration with which the storage devices are assigned when there is a data writing request, the storage region provided by the disk drives  
10 can be utilized efficiently.

In one aspect of the present invention, the disk control system further includes means for responding to the information processing device, when a process command that does not cause a process with regard to the logical device has been received  
15 from the information processing device, by performing a process corresponding to that process command without performing the assignment.

Here, a "process command that does not cause a process with regard to the logical device" is, as explained below, for  
20 example a command such as "Report LUN," "Inquiry," or "Read Capacity" in accordance with the SCSI standard. These commands are commands requesting information regarding the logical unit, so that even if no logical device is associated with that logical unit, a response to that command can be sent back to the  
25 information processing device. Consequently, if a process command is received for a logical unit to which no logical device has been assigned, then limited storage resources can be utilized efficiently without assigning a logical device to that logical unit when receiving such commands. Furthermore, since  
30 no processing is performed with regard to the assigning of

logical devices, a response can be sent back quickly to the information processing device.

In another aspect of the present invention, the disk control system further includes means for assigning a plurality  
5 of the logical devices to one of the logical units, and means for assigning to that logical unit only a number of the logical devices that is necessary in order to perform the processing corresponding to the process command.

For example, if the storage region of the logical units  
10 is larger than the storage region of the logical devices, and the process command is a command for only a portion of the storage region of a logical unit, then there is the possibility that logical devices are needlessly taken up if logical devices are assigned to across the entire storage region of the logical  
15 unit. On the other hand, by assigning a plurality of logical devices to one logical unit, there is the possibility to assign, in steps, only the necessary number of logical devices to the logical unit, so that limited storage resources can be utilized more efficiently.

20 In another aspect of the present invention, the disk control system further includes means for sending to the information processing device a message indicating that the process command cannot be processed, if there is no logical device that can be assigned to the logical unit.

25 Thus, the information processing device can be made aware of the fact that the disk control system cannot process the processing command.

In another aspect of the present invention, the disk control system further includes means for sending to the  
30 information processing device a message indicating that

reading is impossible, if a process command requesting the reading of data from a logical unit to which no logical device has been assigned has been received from the information processing device.

5        Thus, the information processing device can be made aware of the fact that the disk control system cannot read out the data.

      In another aspect of the present invention, if the disk control system has received a process command for the logical unit, and if a logical device is assigned to the logical unit, 10 a process corresponding to the process command is performed with regard to that logical device, and, if no logical device is assigned to the logical unit, a logical device is assigned to the logical unit and a process corresponding to the process 15 command is performed with regard to that logical device.

      Thus, if no logical device is assigned to the logical unit, a logical device is automatically assigned to the logical unit, and the managerial burden on the operator is alleviated.

      In another aspect of the present invention, if the disk 20 control system has received a process command for the logical unit, then, if a logical device has been assigned to that logical unit, a process corresponding to that process command is performed with that logical device; if no logical device has been assigned to that logical unit and that process command 25 is a command that does not cause a process with regard to the logical device, a process corresponding to that process command is performed without assigning a logical device to that logical unit; and if no logical device has been assigned to that logical unit and that process command is a command that causes a process 30 with regard to the logical device, a logical device is assigned



to the logical unit and a process corresponding to that process command is performed with regard to that logical device.

Thus, if no logical device is assigned to the logical unit, and the process command is a command that does not cause a process with regard to the logical device, then a process corresponding to this process command is performed without assigning a logical device to the logical unit, so that a flexible response to process commands becomes possible, and it can be prevented that logical devices are needlessly assigned.

#### *System Configuration*

Fig. 1 shows the configuration of a storage system explained as a working example of the present invention. A disk array device 10 and server computers 20 are connected via fibre channel switches 30. The server computers 20, which are examples of information processing devices, are open-system computers, that is, personal computers or work stations running an open-system OS (operating system). The disk array device 10 includes a plurality of ports 11, which are connected to ports of the fibre channel switches 30, as well as disk drives 12, and a server processor 13.

The storage region provided by the disk drives 12 is managed in units of logical devices (referred to as "LDEVs" in the following), which are logical storage regions that have been set in this storage region. The disk drives 12 may be controlled in RAID (redundant array of inexpensive disks) format, in which case the LDEVs are arranged in RAID groups, which are storage regions provided in the RAID format. It should be noted that in Fig. 1, a configuration is shown in

which the disk drives 12 are accommodated within the casing of the disk array device 10, but it is also possible to accommodate them in a casing that is separate from that of the disk array device 10.

5       The server computers 20 specify the storage region provided by the disk drives 12 in units referred to as logical units ("LUs" in the following). Each LU is given a LUN (logical unit number), which is a unique identifier. In the server computers 20, the LUNs may be drive names, for example, or they  
10   may be device file names, as explained below.

      The specifications for each LU, such as the storage capacity, are set by the operator of the disk array device 10, and stored in a memory (not shown in the drawings) with which the disk array device 10 is provided. Alternatively, the LU  
15   specifications defined by the user with the server computers 20 may be stored in a memory.

      One or more LUs are assigned to each of the ports 11. One or more LDEVs are assigned to an LU. Fig. 2 shows the correspondence relationship between the ports 11, the LUs  
20   assigned to the ports 11, and the LDEVs assigned to the LUs. It should be noted that the assignment of the LUs to the ports 11 and of the LDEVs to the LUs is sometimes referred to as "path definition."

      The assignment of the LUs to the ports 11 and the  
25   assignment of the LDEVs to the LUs can be performed by the operator from the service processor 13. The assignment of the LDEVs to the LUs can also be performed automatically, as will be explained below.

### *Explanation of the Processing*

The following is an explanation of the processing performed in the disk array device 10 when a process command in pursuance with the SCSI standard has been received that has  
5 been sent from the server computers 20 via the fibre channel switches 30.

The following explanations refer to Fig. 3, which is a schematic diagram of the disk array device 10. The disk array device 10 is provided with control processors 14 and local  
10 memories 151 corresponding to the ports 11. Moreover, the disk array device 10 is provided with a shared memory 152, which can be referenced by the control processors 14. It should be noted that the disk array device 10 may also be provided with a cache memory (not shown in the drawings), or other type of  
15 memory, used to read or write data from or into the disk drives 12.

The disk array device 10 stores in the local memories 151 an LU mapping table associating the LUs and DEVs. Fig. 4 shows an example of an LU mapping table 400. The correspondence  
20 between the LUNs and the IDs of the LDEVs ("LDEV#" in Fig. 4) is registered in this table.

The disk array device 10 stores in the shared memory 152 a global LU mapping table, in which the correspondence between the IDs of the ports 11, the LUNs and the IDs of the LDEVs ("LDEV#" in Fig. 5) is registered. Fig. 5 shows an example of a global  
25 LU mapping table. Furthermore, the disk array device 10 stores in the shared memory 152 a global LDEV table tracking whether an LDEV has already been assigned to an LU by setting a flag in correspondence to the IDs of the LDEVs ("LDEV#" in Fig. 6).  
30 Fig. 6 shows an example of a global LDEV table 600.

The process commands in pursuance with the SCSI standard that are sent from the server computers 20 can be broadly classified into process commands that do not cause an input/output process of data with respect to the LDEVs, such as "Report LUN," "Inquiry," or "Read Capacity," (referred to as "type I process commands" in the following) and process commands that do cause an input/output process of data with respect to the LDEVs, such as "Write" (data write command) or "Read" (data read command) (referred to as "type II process commands" in the following). The following is a more detailed explanation of the processing when type I or type II process commands are received with the disk array device 10.

*(1) Type I Process commands*

The following is an explanation of the processing of the disk array device 10, when a type I process command has been received. Fig. 7 illustrates the principle of a type I process command. In this example, a file system such as NFS (network file system) is operated on a server computer, and the LUNs are associated with device files in this file system. In Fig. 7, "/dev/rdisk/c0t1d2" is a device file name, wherein "/dev/rdisk/" is the directory name. Furthermore, "c0" is an identifier for the HBA (host bus adapter) of the server computer, and is ordinarily the WWN (world wide name) of the HBA. "t1" is the ID of the port to which the LU belongs, and "d2" is the LUN.

In this example, a type I process command is sent from a server computer 20 via the HBA and the port 11 to the disk array 10, for the LUN associated with the device file. In Fig. 7, "virtual LUN" is a LUN for an LU to which no LDEV has yet

been assigned. It should be noted that an LU to which no LDEV has been assigned is an LU in which the field LDEV in the global LU mapping table 500 in Fig. 5 has been set to "NULL".

5 If the disk array device 10 receives a type I process command, it generates response data including the necessary information for responding to this process command, and the response data is sent to the server computer 20. Here, the processing for a type I process command is carried out also when the process command is for an LU to which no LDEV has yet  
10 been assigned. The information included in the response data may be stored by the disk array device 10, or it may be collected by the disk array device 10 when a process command is received.

## *(2) Type II Process commands*

15 The following is an explanation of the processing of the disk array device 10, when a type II process command has been received.

First, referring to the flowchart in Fig. 8, the case where the type II process command is "Write" (data write  
20 command) is explained. When the disk array device 10 receives a data write command from the server computer 20 (S811), it references the LU mapping table 400 in Fig. 4, and determines whether an LDEV has been assigned to the LU specified by this data write command (S812).

25 If an LDEV has been assigned (S812: YES), then the control processor 14 performs the data writing for this data write command with this LDEV (S813).

On the other hand, if no LDEV has been assigned (S812: NO), then the control processor 14 retrieves a non-assigned  
30 LDEV from the global LDEV table 600 in the shared memory 152,

assigns the retrieved LDEV to the LU specified with this data writing request, and sets the flag for that LDEV in the global LDEV table 600 to ON ("1") (path definition; S814).

Fig. 9 illustrates the principle of a type II process command. It should be noted that this retrieval algorithm and the selection algorithm deciding which LDEV is selected in case that a plurality of LDEVs have been retrieved can be set in accordance with such circumstances as the user needs and the operation mode of the disk array device 10.

Next, the control processor 14 registers the identifier of the assigned LDEV by associating the LDEV with the corresponding LU of the global LU mapping table 500 in the shared memory 152 (S815). Moreover, the control processor 14 registers the identifier of the LDEV that has been assigned to the corresponding LU of the LU mapping table in the local memory 151 corresponding to that control processor 14 (S816). Then, after that processing, the control processor 14 writes the data for that data write command into the assigned LDEV (S813).

It should be noted that if all LDEVs have been assigned and a data write command is received for an LU to which no LDEV has been assigned, then a message to the effect that assignment is not possible may be sent to the server computer 20.

Moreover, the storage capacity of the LUs may be set such that it is the same as the storage capacity of the LDEVs, but it may also be set to a storage capacity that is different from that of the LDEVs.

Fig. 10 shows an example of an assignment method for the case that the storage capacity of the LUs has been set larger than the storage capacity of the LDEVs. In Fig. 10, a storage

region specified by the LBA (logical block address) 0 .. 2000 is set for the LU with the LUN "LU0," and LDEVs provided with a storage region with a capacity that is specified by LBA 0 .. 1000 are assigned as the storage region of this LU.

5        Furthermore, in this example, two LDEVs are automatically assigned to the LU. That is to say, first, the disk array device 10 receives a data write command 1011 for the LBA 0 .. 100 from the server computer 20, and a number of LDEVs covering a storage capacity corresponding to this LBA 0 .. 100 (here, one LDEV) are assigned to the storage region corresponding to LBA 0 .. 1000 of the LU. Then, the disk array device 10 receives a data write command 1012 for the LBA 500 .. 1500 from the server computer 20, and since the command cannot be handled with only the LDEV that has already been assigned, a new LDEV is assigned 15 as the storage region corresponding to LBA 1000 .. 2000 of the LU.

As has been explained above, with the disk array device 10 of this working example, LDEVs are assigned to LUs to which no LDEV has yet been assigned only after a data write command 20 for that LU has been received. That is to say, an LDEV is assigned to an LU only when it has become necessary, which enhances the efficient utilization of the storage region provided by the LDEVs, that is, the disk drives 12. Furthermore, the assignment of LDEVs to LUs is carried out automatically 25 in this manner by the disk array device 10, so that also the managerial burden on the user or the operator is alleviated tremendously.

Referring to the flowchart in Fig. 11, the following is an explanation of the case that the type II process command 30 is a data read command ("Read"). When the disk array device

10 receives a data read command from the server computers 20 (S1111), it references the LU mapping table 400, and determines whether an LDEV is assigned to the LU specified by this data read command (S1112).

5        If an LDEV is assigned (S1112: YES), the control processor 14 reads out the data from the LDEV in accordance with this data read command (S1113).

         On the other hand, if no LDEV is assigned (S1112: NO), then the control processor 14 sends to the server computer 20  
10 a message stating that the processing of this data read command is not possible (S1114).

         The foregoing explanations were for a disk control system in accordance with the present invention, but the above-described embodiments of the invention are merely given  
15 to facilitate the understanding of the present invention, and the present invention is not limited thereto. Modifications, improvements and equivalents not departing from the spirit of the present invention are intended to be included therein.

         The present invention provides a disk control system and  
20 a control method for a disk control system.

         Although the preferred embodiment of the present invention has been described in detail, it should be understood that various changes, substitutions and alterations can be made therein without departing from spirit and scope of the  
25 inventions as defined by the appended claims.